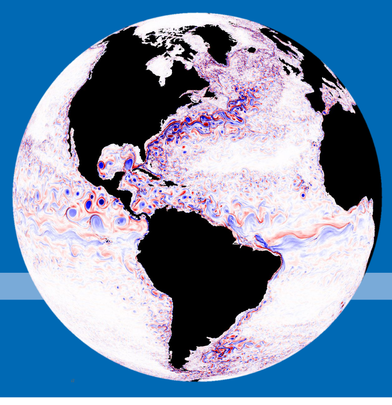


Computing performance matters to EC-Earth

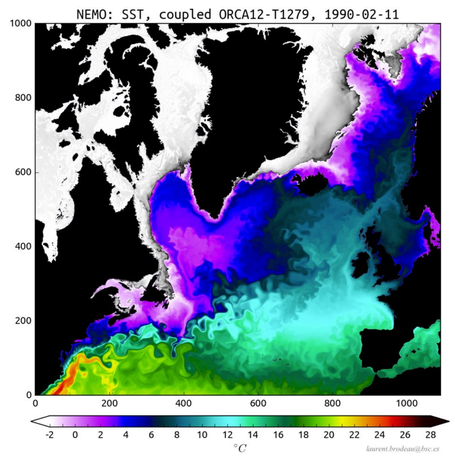
Performance Team

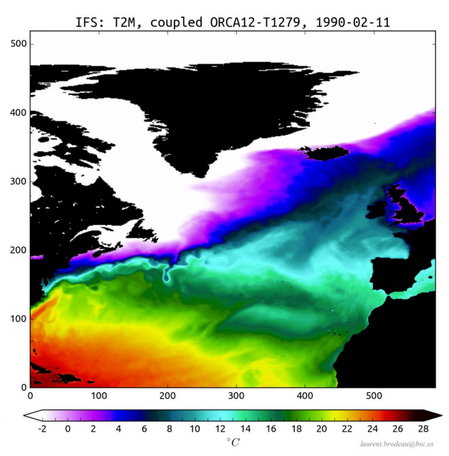
Earth Sciences Department, Barcelona Supercomputing Center (BSC), Spain

Motivation

Earth System Models (ESMs) consume billions of computing hours every year. Our motivation is to optimize these models to **save both time and energy**, and **allow further increases in resolution** to improve their capabilities of simulating small-scale features and reduce the impact of the parametrizations.

Global **ESMs are complex** systems made of heterogeneous components, that require a substantial amount of studies to work correctly and use the resources wisely. The goal of running these models using grids on the order of 1 km will be impossible to achieve without using adequate optimization techniques.





Daily mean of: sea surface temperature (NEMO, left) and 2m air temperature (IFS, right) from a ORCA12-T1279 EC-Earth coupled simulation. The influence of the sea surface temperature (cold eddy detaching from the Gulf Stream) on lowest layer of the atmosphere can be clearly observed.

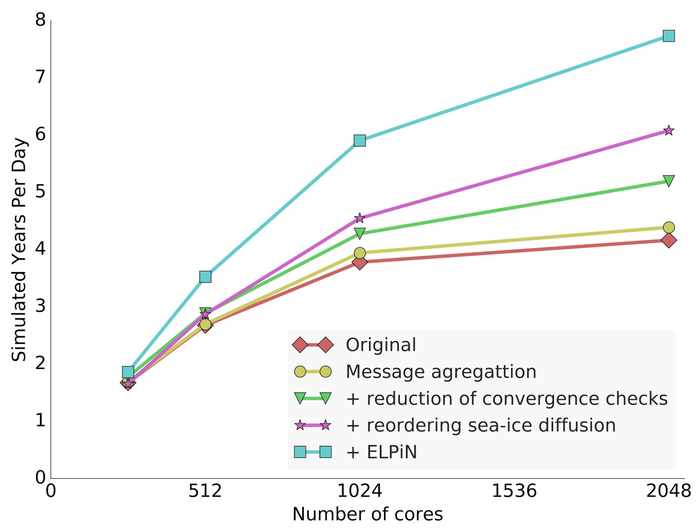
Examples - Success stories

Squeezing NEMO's capabilities. A performance analysis and optimization work [1], carried on with the BSC performance tools [2], led to substantially improve the model throughput by tuning the communications routine to minimize the quantity of exchanged messages within NEMO.

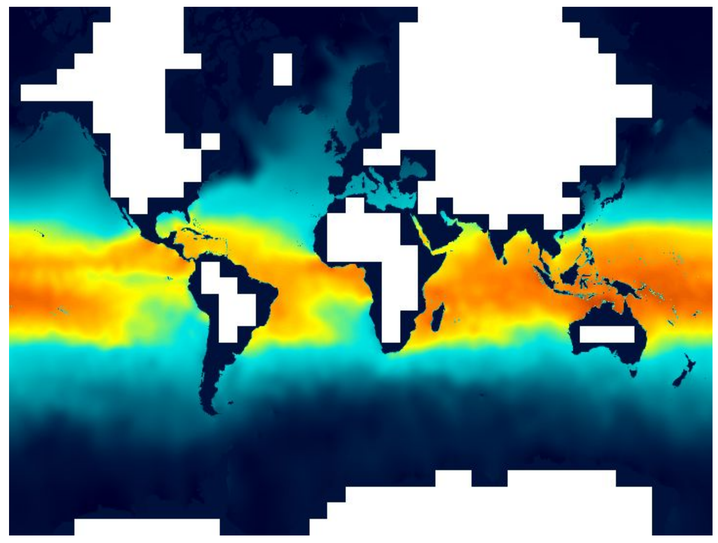
Why computing land processes? ELPiN (Exclude Land Processes in NEMO) is a new tool for finding the optimal domain decomposition for the NEMO model, with any number of processes, giving the chance to omit the land subdomains and reinvest the resources saved in useful computation.

Taking apart the EC-Earth coupling. A comprehensive evaluation of the EC-Earth coupling allowed us to suggest two optimizations, which dramatically reduced the time needed to synchronize and interchange model data.

Spreading the word. A performance analysis using the BSC tools was done in collaboration with the Research department at ECMWF. Some bottlenecks were highlighted thanks to this study. Moreover, BSC tools for profiling and possible optimizations will be integrated in the next official release of IFS.



Impact of optimizations done on the NEMO model for an ORCA025-LIM3 simulation.



Example of NEMO domain decomposition by using ELPiN land processes removal.

Our methodology

Complex models require complex studies. And several approaches are needed to optimize an ESM:

Mathematical study

Discretization used (explicit, implicit, semi-implicit…)
Parallel implementation (solvers, preconditioners…)

Computational study

Reduce overhead introduced by parallel applications
Ensure that the computational algorithm takes advantage of the architecture

Profiling Study

General profiling
Specific profiling oriented to Earth System Models

Introducing optimizations

Improvement of the algorithm
Change the method using a new approach

Reproducibility study

Keeping in mind the chaotic nature of climate models, evaluate the impact in accuracy and reproducibility of the model after applying the proposed optimizations [5]

Next? Future plans

We are carrying on a study to know the impact that a reduction of **unnecessary numerical precision** would have in NEMO. Preliminary results show a **potential 40% improvement** in computational performance on an ORCA025-LIM3 grid, by only using the mixed precision approach in the ocean component.

Profiling study for IFS highlighted **possible optimizations** for the **OpenIFS version of EC-Earth**.

We will **compare two different coupling methods** (single binary vs. multiple independent components), in collaboration with ECMWF and CERFACS.

We are working in the **integration of XIOS into OpenIFS**, to improve the parallel performance and functionality of the model.

How can we colaborate?

The **Technical Working Group** monthly meetings should work to discuss all the performance issues.

All developments should be able to be tracked in the EC-Earth development portal.

Are you experiencing performance issues? Are you developing a new feature that could be sensible in terms of performance? In that case, open a ticket into the portal.

29 partner institutes
8 core partners
KNMI, AEMET, DMI, Met Éireann, FMI, IPMA, CNR-DTA, SMHI
Work groups
Technical
Tuning
Atmospheric Composition and Land
Ocean
Millennium scale studies
CMIP6

About us

The **Performance Team** is part of the **Computational Earth Sciences** Group (CES), at the **BSC Earth Sciences Department**.

The mission of **CES** is to ensure the efficient use of the computational resources by the Earth scientists, to develop Earth Sciences related HPC user-friendly software and to provide computational services to the department and the Earth sciences community.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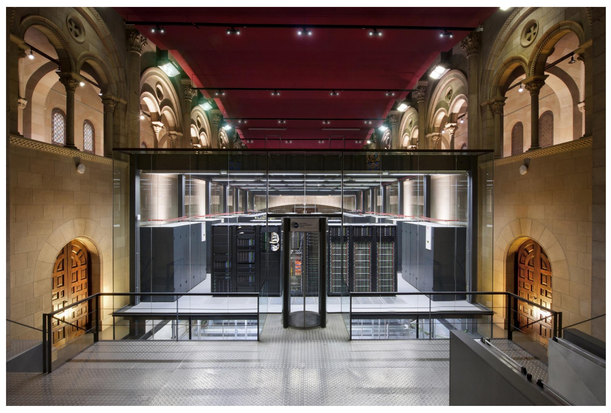
Marenostrum III Supercomputer

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[4] Barcelona Supercomputing Center. BSC performance tools, 2016: https://tools.bsc.es/

[5] Acosta, M.C. at al., 2016: "Reproducibility of Earth System Models". Barcelona Supercomputing Center

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This poster can be downloaded at
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